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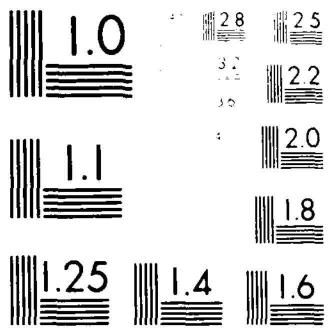
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THESIS

A STUDY OF THE DEPARTMENT OF DEFENSE CONFIGURATION MANAGEMENT POLICIES AND PROCEDURES AS APPLIED TO THE FA-18 STRIKE/FIGHTER PROGRAM

by

Christopher J. Roum

June 1987

Thesis Advisor: Paul M.Carrick

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This thesis appraises the costs and benefits of the Department of Defense (DOD) and the Department of the Navy (DON) Configuration Management (CM) program but only so far as to identify the present costs and benefits and their relationship. The FA-18 program is utilized as the research vehicle and is examined in terms of configuration management and control policies and procedures. The focus is on post-production-baseline configuration control. An overview of critical CM issues in the government/contractor relationship is presented and their impact on the FA-18 program is analyzed. It was determined that current policies and procedures cannot insure control of the product baseline in highly

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19. Abstract (Continued)

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A Study of the Department of Defense Configuration Management Policies and Procedures as Applied to the FA-18 Strike/Fighter Program

by

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ABSTRACT

This thesis appraises the costs and benefits of the Department of Defense (DOD) and the Department of the Navy (DON) Configuration Management (CM) program but only so far as to identify the present costs and benefits and their relationship. The FA-18 program is utilized as the research vehicle and is examined in terms of configuration management and control policies and procedures. The focus is on post-production-baseline configuration control. An overview of critical CM issues in the government/contractor relationship is presented and their impact on the FA-18 program is analyzed. It was determined that current policies and procedures cannot insure control of the product baseline in highly sophisticated and broadly integrated weapon systems. Responsibility for CM is too fragmented and the system too cumbersome to allow effective and efficient information flow. In most cases, CM inefficiencies identified in the FA-18 program were previously addressed by program management and extraordinary work arounds implemented to ensure future FA-18 supportability. Recommendations for improvement of Configuration Management and Control for future programs are made.

TABLE OF CONTENTS

LIST OF FIGURES

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To Professor Paul M. Carrick for his guidance, criticism and assistance during the research.

Finally, to my wife Deanie, whose patience and support were indispensable.

I. INTRODUCTION

A. OVERVIEW

The purpose of this thesis is to appraise the costs and benefits of the Department of Defense (DOD) and the Department of the Navy (DON) Configuration Management (CM) program but only so far as to identify the present costs and benefits and their relationship. CM costs occur in the implementation and application of policies, procedures, methods and techniques while CM benefits are traceable in how the CM policies affect overall Integrated Logistics Support (ILS) of a major weapons system. The FA-18 Hornet aircraft program will be studied and utilized as an example of the costs and benefits associated with Configuration Management and Control. Primary focus for this thesis is Configuration Management after Product Baseline has been established and the weapon system is in full scale production and deployed to the fleet. This chapter will provide a definition of Configuration Management and Configuration Control together with a brief history of configuration management, a statement of the research problem, a statement of the research objectives and a statement of the research methodology.

B. DEFINITION OF CONFIGURATION MANAGEMENT AND CONTROL

Configuration Management as a concept or technique embodies many critical and essential disciplines. Configuration control, identification and accounting are

elements crucial to the overall objective of managing advanced technology (see Figure 1). Indeed, these elements are implicit in one widely used definition:

> Configuration Management is the discipline of ensuring that equipment or hardware meets carefully defined functional, mechanical, and electrical requirements and that any changes in these requirements are rigidly controlled, carefully identified, and accurately recorded. (Ref. 2:p. 313)

Configuration control can be defined as that function responsible for the evaluation, approval, disapproval, and implementation of approved changes to the original Configuration Item (CI). It also refers to the procedure by which changes to baseline configured items are proposed and formally processed. Additionally:

> Configuration control involves the systematic evaluation, coordination, and approval or disapproval of proposed changes to the design and construction of a CI whose configuration has been formally approved internally by the company or by the buyer, or both. (Ref. 1:p. 7)

Configuration identification is the process of identifying specifications, hardware, and data available at the start of a system development. It is also the term used to identify the currently approved or conditionally approved technical documentation for a configuration item. More formally, it:

> . . . refers to the technical documentation that identifies and describes the approved product configuration throughout the design, development, test, and production tasks. It also applies to the identification of changes and to product markings. (Ref. 1:p. 7)

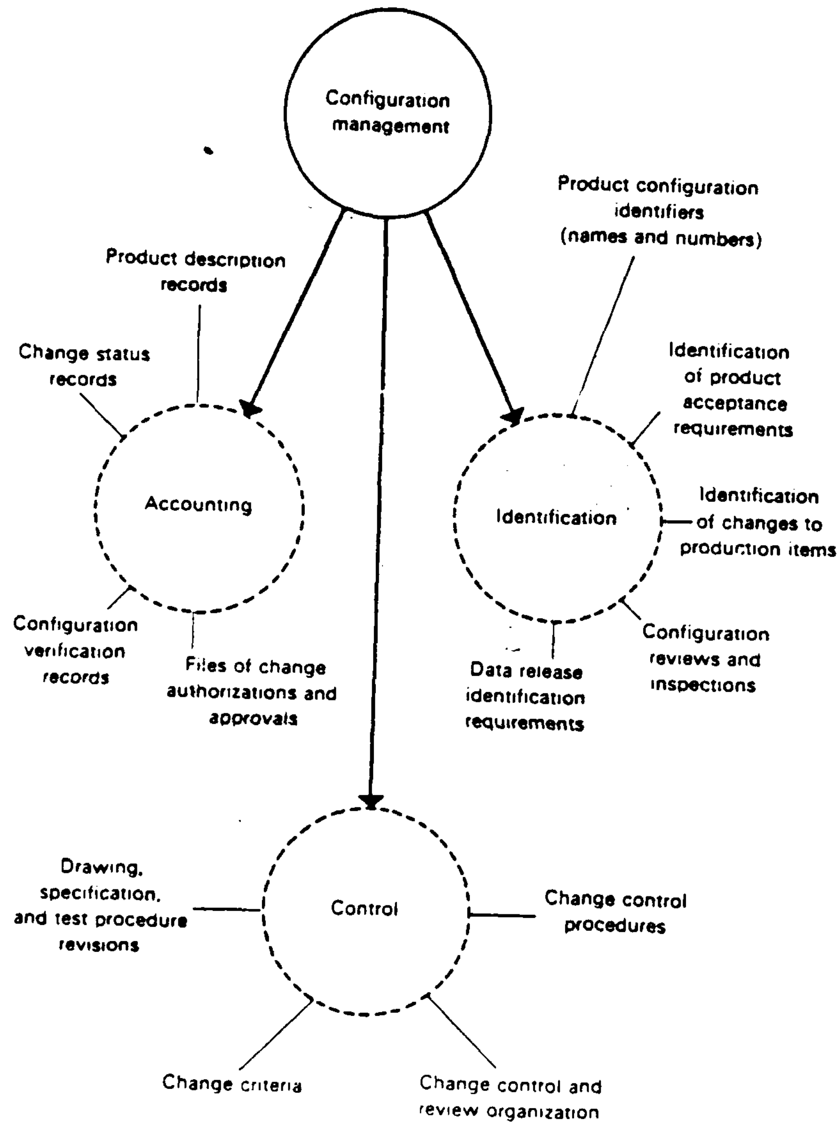

Figure 1. Major Facets of Configuration Management (Ref. 1)

Configuration accounting is referred to as the reporting and documentation activities involved in keeping track of the status of a CI to include all departures planned or made from the configuration at all times throughout the entire lifetime of the system. A more accurate definition is:

> . . . the systematic recording and reporting of information vital to the total configuration management task, a listing of the approved configuration items, and the listing of configuration identification approved for technical documentation of all configuration items. (Ref. 3:p. 26)

Inherent to these formal and informal definitions are words like discipline, systematic, precision and organization which imply a formal, structured, and responsive program dedicated to the configuration management objective.

The overall objective of configuration management can be stated as:

> . . . to guarantee the buyer that a given product is what it was intended to be - functionally and physically, as defined by contractual drawings and specifications and to identify the configuration to the lowest level of assembly required to assure repeatable performance, quality, and reliability in future products of the same type. (Ref. 1:p. 7)

Five major goals are commonly an integral part of the configuration management effort. They are:

1. **Definition** of all documentation required for product **design,** fabrication, and test.

2. **Correct** and complete descriptions of the approved **configuration.** (Including drawings, parts lists, specifications, test procedures, and operating manuals.)

3. Traceability of the [illegible] and their descriptions.

4. **Accurate** and complete identification of each material, **part**, subassembly, and assembly that goes into the **product**.

5. Accurate and complete pre-evaluation [illegible] and accounting of all changes to product descriptions and to the product itself. (Ref. 1:p. [illegible])

The amount of data to be identified, controlled and accounted for can present an awesome task for a program manager. While the data required to satisfy the stated goals is usually available from the contractor in one form or another via the Contract Data Requirements List (CDRL), the complexity of configuration management activities is often beyond the scope of the program manager. Yet it is important to understand a weapon system's ownership [illegible] control procedures should eliminate the [illegible] but [illegible] changes that keep designs in a state of [illegible] to [illegible] litigation, and unnecessarily burden the [illegible] support system and training program. Configuration [illegible] should not become so strict and burdensome as to [illegible] inhibit the design maturation process. Change will always **be** **necessary** to enhance design attributes such as reliability, maintainability, and producibility [illegible] latent **design** deficiencies [illegible] revealed by [illegible] test and evaluation (DT&E) and production acceptance test and evaluation (PAT&E) programs; to embrace applicable new technology, and to accommodate changing [illegible] threat [illegible] [illegible]

accounted for in the management system, they can significantly enhance the utility of the weapon system. (Ref. 4:p. 4-88)

C. BACKGROUND

During World War II aircraft rolling off the production line were inconsistent. That is to say that while an aircraft type was mostly hand made with some automated manufacturing, each aircraft had subtle differences as a result of the labor intensive manufacturing processes. Systems were basic, sophistication was relatively low and online maintenance of electronics and avionics systems was minimal. As sophistication expanded during the post war period, air bases and aircraft carriers devoted more space and time to the support of airborne electronics, avionics, power plants and structural sub-systems. Multiple configurations of components often went undiscovered until maintenance, troubleshooting, spares interchangeability, and supporting documentation presented compatibility problems. The first formalized program to effectively deal with uncontrolled changes was ANA Bulletin (Army, Navy and Air Force) No. 390 issued by the Office of the Secretary of Defense (OSD). This document introduced the Engineering Change Proposal (ECP) which formalized industry guidelines for proposing aircraft changes. ANA Bulletin No. 391A took ECP's a step further by establishing a classification of priority and forcing the requirements on the electronics and

ground support equipment industries. In 1963, ANA Bulletin 445 was issued as a refinement by consolidating the previous bulletins into one document and further specified procedures for the submission of ECP's for government approval. Additionally, it included reliability and maintainability as elements requiring consideration as Class I changes. The present standard which superseded ANA Bulletin 445 is MIL-STD-480A. Entitled "Configuration Control Engineering Changes, Deviations and Waivers", it represents the most complete description of change control. (Ref. 1:p. 16) All DoD activities involved in the procurement business recognized the need for Configuration Management and a proliferation of individualized instructions ensued. In 1962 the Air Force published AFSCM 375-1 entitled "Configuration Management During the Development and Acquisition Phase". In 1964, DOD released DOD Directive 3200.9 covering the requirements for concept formulation and contract definition. Also in 1964, NASA published NPC 500-1, "Apollo Configuration Management Manual". In 1965 the Army had AMCR 11-26 which was similar to that of the Air Force. The Navy published many different documents specializing down to the project level. While MIL-STD-480 represented the most complete description of change control, it did not provide implementation procedures, nor did it address any type of system approach to management. The frustrating result of

this proliferation of documents was that [illegible] agency had achieved a working system suited [illegible] particular needs, major contractors and subcontractors now had to contend with multiple requirements. [illegible] they were similar in concept but encompassed a multitude of variants in the details of significant tasks and [illegible] requirements. (Ref 1:p. 19)

Finally, in 1968, OSD took the lead by promulgating a cease and desist order and providing new guidance in an attempt to achieve a conceptually more consistent degree of uniformity in regard to policy, procedures, data forms, and reports at all interfaces within the DOD and between DOD and industry. DOD Directive 5010.19 issued on July 1, 1968 established Configuration Management policy as it exists today. DOD Instruction 5010.21 provides implementation procedures for all services and other DOD activities [illegible] Figure [illegible]. While these guidelines are very [illegible] followed almost to the letter within the Navy, [illegible] shown that there is significant room for [illegible] especially in the handling of Class II changes.

[illegible]. PROBLEM STATEMENT

The F/A 18 Hornet represents a [illegible] technological refinement and systems [illegible] [illegible] significant amount of [illegible] [illegible] fault isolation [illegible] [illegible] requirement [illegible]

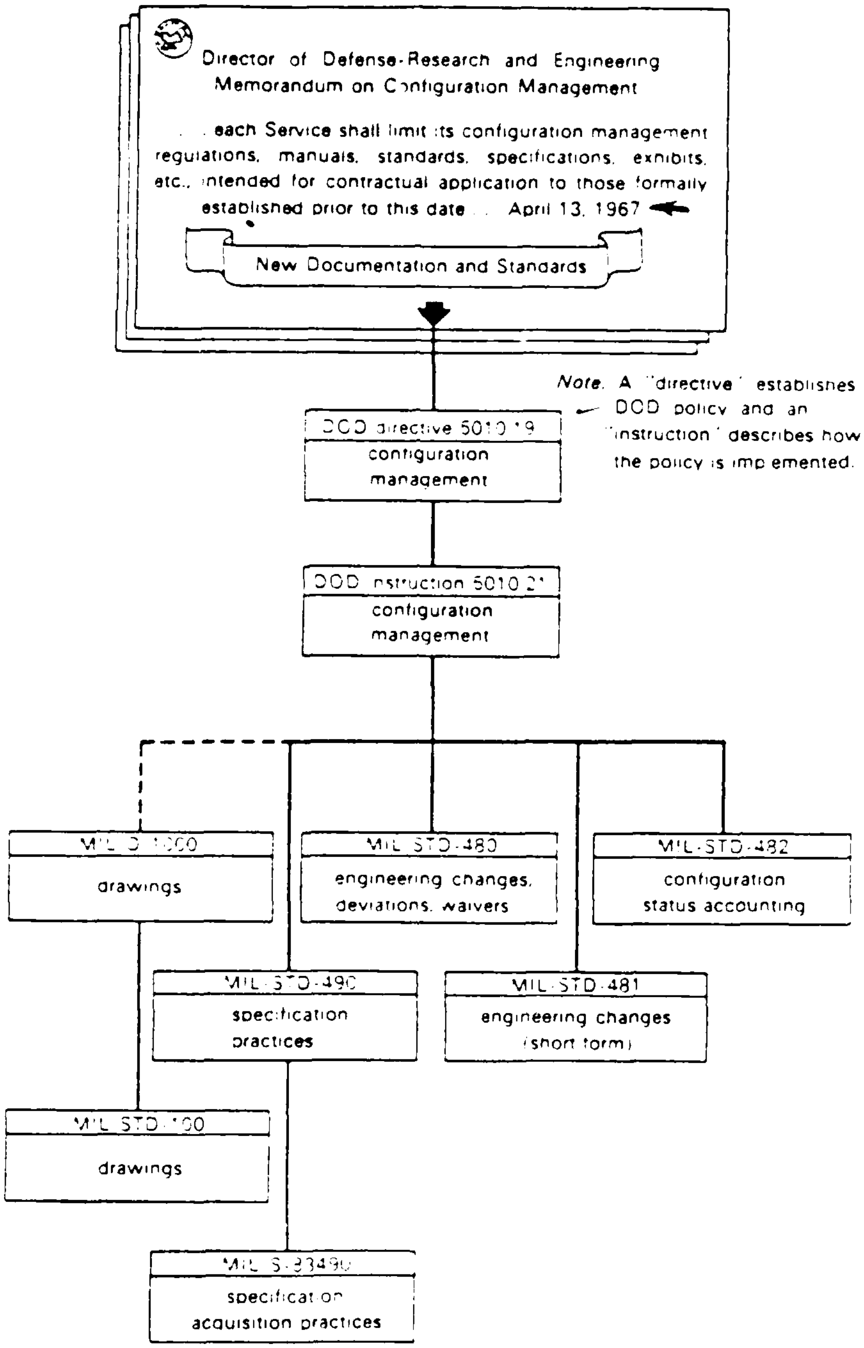

Figure 2. DOD Configuration Management Standards (Ref. 1)

intermediate and Depot levels of maintenance, technicians are discovering that some Weapon Replaceable Assemblies (WRA's) and Shop Replaceable Assemblies (SRA's) are not functioning as they should on Automatic Test Equipment (ATE). Additionally, certain part numbers which should have a relatively fixed configuration are showing up in multiple configurations. Aside from the costs incurred to research actual part numbers and their application, program officials view this problem as a significant safety issue as well as a source of degradation of operational readiness. This results from incorrect orders by technicians and dysfunctional maintenance programs on ATE.

[illegible]. RESEARCH OBJECTIVE

The purpose of this thesis is to investigate the [illegible] [illegible] benefits of the [illegible] Configuration Management [illegible] and procedures, [illegible] the F/A-18 program [illegible] [illegible] vehicle. The focus will be on post production [illegible] the configuration control in an attempt to discover why [illegible] functional configurations are possible under one part number.

[illegible]. RESEARCH QUESTIONS

The primary research question is derived from the research objective and is, "Has the Navy's Configuration Management program for the F/A-18 aircraft effectively

controlled the product baseline for all [illegible] Configuration Items." Secondary research questions are: (1) Has the complexity of configuration control problems [illegible] tripped the present system's ability to handle them?; [illegible] the present system inadequate and unable to [illegible] the current fast paced, high technology environment?; [illegible] there existing methods used in private industry [illegible] adequate configuration control?; (4) Who has [illegible] responsibility and authority for configuration management?; [illegible] Does the Program Manager have the tools and expertise he needs to manage configuration baselines?; [illegible] responsibility for configuration management and control [illegible] fragmented or inadequately defined?; (7) Are procedures well defined and adequately enforced?; (8) Is configuration management being delegated to a level beyond the [illegible] the existing DON or Naval Air Systems Command (NAVAIR) [illegible] directives?; (9) Is the system too cumbersome to [illegible] effective and efficient information flow?; (1[illegible] and third tier vendors (manufacturers) [illegible] the present system to avoid what may be bureaucratic bottlenecks?; (11) Do contractors fully understand [illegible] Configuration Control requirement and the significant logistics impact of a deviation from the requirement?

[illegible]. METHODOLOGY

This research effort will be conducted through the [illegible] of applicable trade journals, periodicals and previous

research reports. Historical and current publications and literature on relevant subjects have been utilized. All applicable Department of Defense (DOD) and Department of the Navy (DON) instructions, directives and regulations have been reviewed. Personal interviews were conducted at NAVAIR-SYSCOM in the FA-18 Program Management Office (PMA 265) with the Configuration Manager, the Assistant Program Manager for Logistics (APML) and with personnel of Information Spectrum Inc., under contract to the PMA for logistics matters. Personal interviews with other key personnel in the FA-18 support structure include the NAVPRO at McDonnell Aircraft Corporation (MCAIR) in St. Louis, MO, the staff of Commander, Naval Air Forces, Pacific Fleet (COMNAVAIRPAC) San Diego, CA, the Naval Engineering Services Office (NESO) at the Naval Aviation Depot, North Island, CA. In addition, phone conversations with the Aviation Support Office (ASO) in Philadelphia, PA and with the DOD Configuration Manager in Washington D.C. are other information sources.

II. DOD/DON CONFIGURATION MANAGEMENT PROGRAM

A. OVERVIEW

This chapter will describe configuration management and control as required within DOD and as applied to private industry. A great deal of research has been done and much has been written about configuration management. Many directives, instructions and regulations govern DOD configuration management. It is not the purpose of this thesis to recapitulate the entire body of information available on configuration management. Inefficiencies that are observable in most weapon system procurements will be addressed, particularly if they are visible in the FA-18 program.

All controlling documents center around MIL-STD 480A. While the central focus is the configuration disciplines of control, identification and accounting, the most distinguishing feature is the separation of Class I and Class II changes. Conversations with logisticians and configuration managers indicate that the definition of a change and a determination as to which category it falls into is often vague and ambiguous and subject to time, fiscal, and political pressures.

B. DOD/DON CONFIGURATION MANAGEMENT AND CONTROL STRUCTURE

All DOD components, including the Office of the Secretary of Defense, Military Departments and Defense Agencies, are governed by DOD Directive 5010.19 dated 01 May 1979, entitled "Configuration Management". This directive states general policy for the heads of all DOD components in the application of configuration management practices. In addition, it directs the Secretary of the Navy to maintain the Joint DOD Services/Agencies Regulation, the purpose of which is to:

> . . .prescribe uniform policies and guidance for the Military Services and Defense Agencies (hereafter referred to as DOD components) responsible for implementation of Configuration Management within the Department of Defense. (Ref. 5:p. 1-1)

The applicability of this instruction is extremely broad in an attempt to capture all possible DOD demands. At the same time, it recognizes that no single common set of configuration management procedures will meet every DOD need. It further states:

> Due to variations in requirements, organizations, industrial commodity areas, and working relationships, the military specifications (MIL-SPECs) and standards (MIL-STDs) (prescribed herein) will be tailored to recognize peculiar program requirements. However, optimum uniformity throughout DOD and between DOD and Industry components can be achieved by Service/Agency adherence to the policies outlined herein coupled with reasonable contractual application of the prescribed MIL-SPECs/STDs and applicable Data Requirement Descriptions (DD Forms 1664) for citation in the DD 1423 Contract Data Requirements List. (Ref. 5:p. 1-1)

The concept of standards and specifications as to their application and enforceability is often misconstrued. As utilized above, the DOD perspective of a standard to describe products or services generally falls into three categories. A standard can be written as a set of technical, dimensional, or performance requirements. It can be an accepted process or procedure. It can also be a common product identified as a preferred item in a situation. These standards should not be confused with those "standards" mandated by law or regulation at the federal, state, and local levels which are used to establish requirements for meeting safety, environmental protection, welfare and other national objectives. (Ref 6) A representative sample of standards which should be contractually specified is provided in Appendix A.

Since a standard or specification as defined above does not carry the weight of the law except as enforced through a contractual vehicle, and in view of the flexibility provided by the Joint DOD Services/Agencies Regulation, the various Systems Commands within the Navy have been delegated the responsibility of generating more specific guidance for the application of standards and specifications to configuration management. Of particular interest to this study is NAVAIR Instruction 4130.1A, the Configuration Management Manual. The foundation for this instruction, which provides specific

guidance to all programs under NAVAIRSYSCOM cognizance, and MIL-STD-480A which supplies change control guidance to both DOD and private contractors. Structurally, both documents are broken down into the major disciplines outlined in chapter one of this study. However, a recurring theme, one of significant consequence in the FA-18 acquisition, is the requirement within all aspects of configuration management, to categorize changes into two classes. Class I changes are the most consequential in terms of costs and are called Engineering Change Proposals or ECP's. Class II changes are simply all other changes that do not qualify as Class I's. It will be shown that these two classes are extremes in the world of change and the criteria for their respective definitions is often more ambiguous than precise. In order to understand the full significance of this division, a brief overview of both categories is necessary.

C. CLASS I ECP'S

Class I ECP's are those changes which are necessary, or which offer significant benefit to the government. (Ref. 7:p. IV-8) Such changes are those required to:

1. correct deficiencies,
2. make a significant effectiveness change in operational or logistics support requirements,
3. effect substantial life cycle cost savings, or
4. prevent slippage in an approved production schedule.

While these criteria appear rather subjective, MIL STD 480A presents a more objective check list for the classification of engineering changes (see Appendix B: Check List for Classifying ECP's). More precisely, an engineering change is classified Class I when one or more of the factors listed are affected. Once it has been determined that a change is a Class I ECP, it must be fully justified and documented by the manufacturer to the NAVAIRSYSCOM Change Control Board Secretariat, Code AIR-01D4. MIL-STD 480A provides a series of applicable justification codes. After justification and preparation in the format specified by NAVAIR Instruction, it is processed through the NAVAIR chain of command as illustrated in Figure 3. Class I changes have priority assignments with specified time allowances for the processing of more critical changes. An Emergency ECP time allowance is 24 hours; an Urgent is 15 calender days; a Routine is 45 calendar days. From the processing diagram it can be seen that many potential bottlenecks can exist due to time, fiscal and political constraints. The most notable of which was the decision by Navy Secretary John Lehman to personally approve all ECP's for major weapon systems. Though this is undoubtedly an extreme, and will not continue in the future, many other factors are at work preventing timely processing of Class I ECP's. The average processing time is currently running approximately 24 months for a

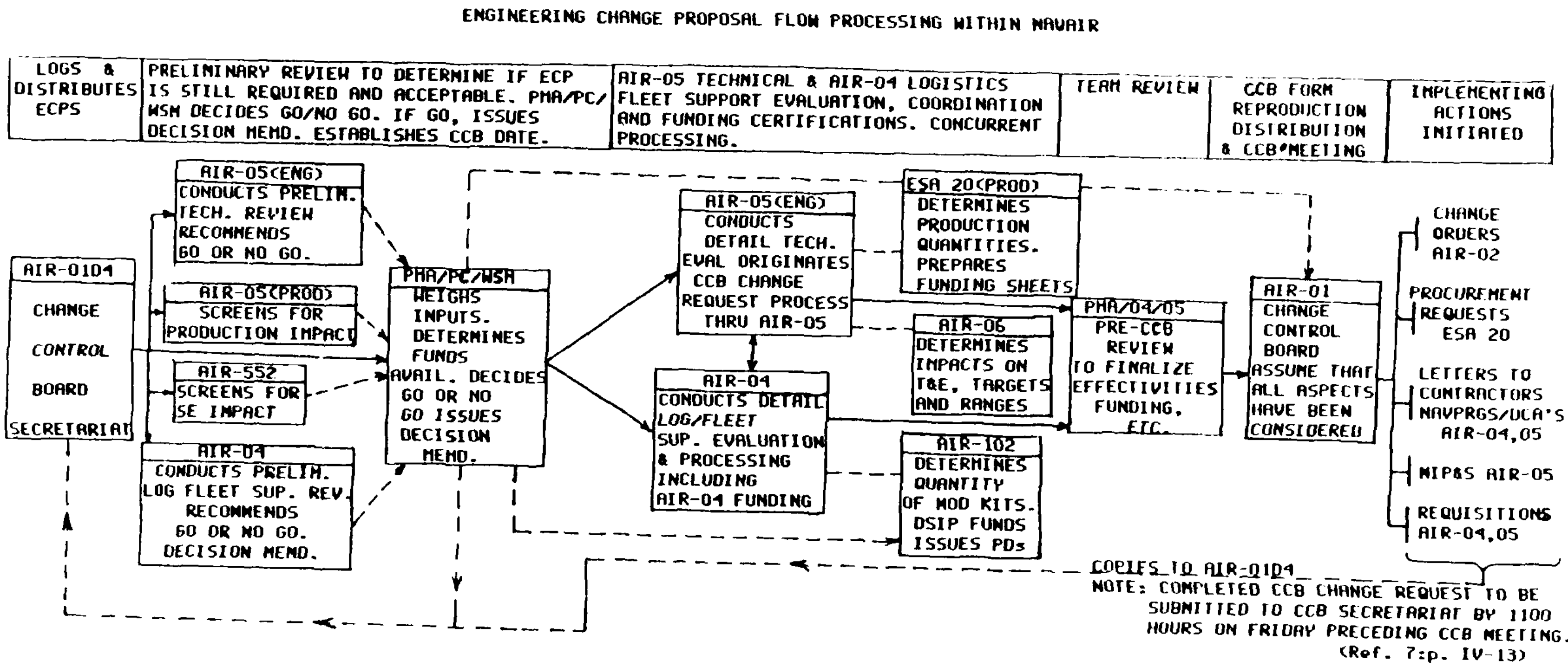

Figure 3. Engineering Change Proposal Flow Processing Within NAVAIR

[illegible] ECP. (Ref. [illegible]) The [illegible] Class I through the system is [illegible]. For Safety ECP's, processing is without hesitation. For all others, however, funding seems to be the most [illegible] constraint. (Ref. [illegible])

Figure 4 offers a sampling of funds available for different types of changes and modifications, and as with all appropriated funds in DOD, each must be budgeted. Therefore, surprises in the form of Class I ECP's can have a significant impact on fiscal allocations thereby requiring action on an ECP to be postponed until actual funding is available. If transfer funding cannot be agreed to, and a supplemental appropriation cannot be justified to Congress, a delay of up to a year or more can be expected. [illegible] infighting over protection of scarce resources is a way of life for all program managers. An ECP is just a proposal until it is funded and approved. Upon approval, an ECP becomes incorporated into the production line for all future items, and/or becomes part of the Navy Modification Program for retrofit on deployed units.

D. CLASS II CHANGES

If Class I ECP's are [illegible] to approve [illegible] easiest to trace, Class II changes are [illegible] approval but the most difficult to trace. [illegible]

FUNDING MATRIX

CAUTION: USE AS A GUIDELINE ONLY. CONSULT AIR-08 FOR ADVICE.

ELEMENT	PRODUCTION	RETROFIT	ATTRITION	COG CODES
APN-1 THRU 4				PMA/APC
NON-RECURRING (ENG. CNGs, TDs, SICRs)	X	X		
PUBS/TAPES	X			
TRAINERS	X			
SUPPORT EQUIP.	X			
APN-5				AIR-102
NON-RECURRING		X		
A/C AND ENGINE MOD KITS		X		
CONTRACTOR MODS		X		
TRAINERS/TRAINING		X		
CILOP/SLEP		X		
APN-6				AIR-412
SPARES (NEW & REPLEN.)	X		X	
KITS TO UPDATE SPARES		X		
SPARES MOD (CONTRACTOR)		X		
PGSE REPAIR PARTS	X			
APN-7				
A/C SUPPORT EQUIP.	X		X	AIR-552
COMPONENT IMPROVE PROG.		X	X	AIR-536
OPNL. TRNG. DEVICES			X	AIR-413
OTHER PROD. CHARGES	X			
WPN-2				
MISSLES	X			PMA
GUNS	X			AIR-541
SUPPORT EQUIP.	X			AIR-552
AERIAL TARGETS	X			AIR-630
OPN-3				
SUPPORT EQUIP.	X	X		AIR-552
AIR LAUNCH. ORD/ASW	X	X		AIR-541
PHOTO. EQUIP.	X	X		AIR-547
A/C LAUNCH & RETRVL.	X	X		AIR-551
O&MN				AIR-04
SDLM A/C MOD.		X		NALC
DEPOT MOD OF SPARES		X		AIR-412
RAMECs		X		AIR-0444

(Ref. 7:p. C-1)

Figure 4. Funding Matrix

engineering changes are generally defined as those [illegible] which do not fall under the Class I definition. (Ref. [illegible]: IV-[illegible]) In other words, any change that is not a Class I, is a Class II. An alternative definition might be one that [illegible] tinguishes a Class II engineering change as having no effect [illegible] [illegible], function or cost. All others then would be Class I. An example of a Class II engineering change might be a change in documentation (correction of errors, addition of clarifying notes or views), or a change in hardware (e.g., substitution of alternative material) which does not affect any factor listed in the definition of a Class I change (see Appendix B). It is hard to imagine a change which does not affect at least one of the Class I [illegible] [illegible]. It will be shown that most changes have [illegible] same effect on publications.

The approval authority for a Class II engineering [illegible] is at a much lower level than that for a Class I ECP. NAVAIR Instruction 4130.1A states in part:

> Unless otherwise specified by contract, the only [illegible] ment review of Class II changes will be for [illegible] classification. This function is performed by the NAV[illegible], DCASMA, NTR or other designated Government Repr[illegible] servicing the contractor's plant. (Ref. 7:p. IV-9)

Implied in this statement of responsibility [illegible] review of engineering applicability. The variabilit[illegible] review is subject to many factors such as:

1. The number of qualified engineers assigned [illegible] Government Plant Representative office,

2. [illegible] the review,

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] authority extends beyond the prime [illegible] weapon system like the FA 18, to [illegible] and third tier vendors and creates a very shallow approval chain which requires limited if any formal documentation. The potential to lose track of these "informal" changes is great. In many cases, the only place a change might be visible is on the engineering drawings themselves.

Many of the lower level vendors manufacture items with multiple applications in and to different weapon systems. It is fundamental to the Engineering discipline that [illegible] changes take place to enhance performance objectives such as Reliability, Maintainability or Survivability. Indeed, Figure 5 which illustrates recent Class II change activity at MCAIR, provides some idea as to the magnitude of the change process.

Given the loose requirements for approval of Class II changes, it is not surprising that the identification [illegible]

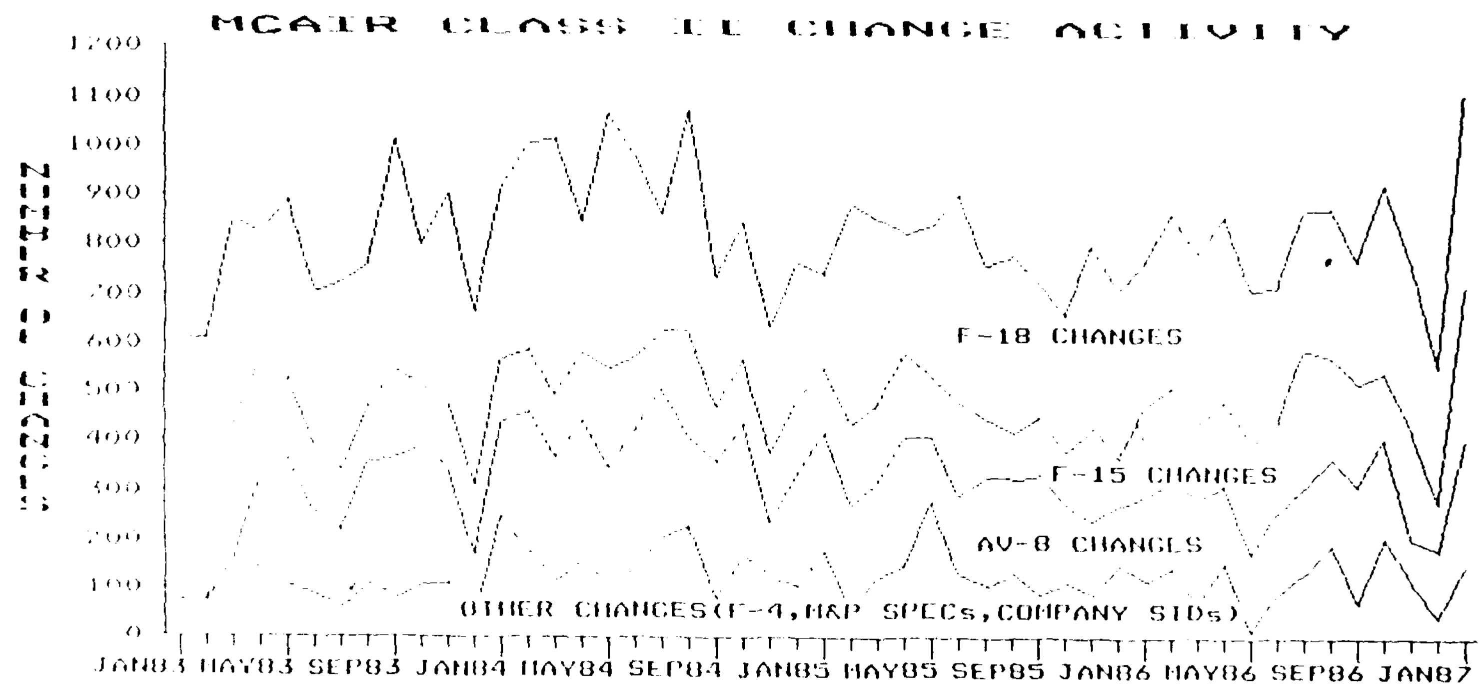

Figure 5. MCAIR Class II Change Activity
(Ref. 8)

[illegible] counting function is limited in its ability to [illegible] changes and properly [illegible] them.

[illegible] GOVERNMENT MOTIVATIONS (REPRESENTATIVE VIEWPOINTS AND ATTITUDES)

The primary purpose of configuration management, [illegible] the [illegible] time, is to ensure the continuing [illegible] supportability of systems in the government inventory. [Ref. [illegible]] It should be obvious by now that significant constraints are placed on changes qualifying as Class I's. Consequently, almost through default, Class II engineering changes are the politically preferred method. Considerable time and energy are expended by Navy managers and by contractors to rationalize an engineering change into a Class II category rather than the burdensome, tedious and [illegible] Class I ECP process. This is not to say that changes are intentionally misclassified. It does show that there is no middle ground for managers to work in. [illegible] change can avoid a corpulent bureaucracy. [illegible] can sidestep sensitive funding issues, and [illegible] a relatively negligible amount of time. A [illegible] extremely unwieldy, inflexible and [illegible] provide uncompromised accounting procedures [illegible] is critical when the [illegible] function [illegible] from the manufacturer, [illegible] late in the [illegible]

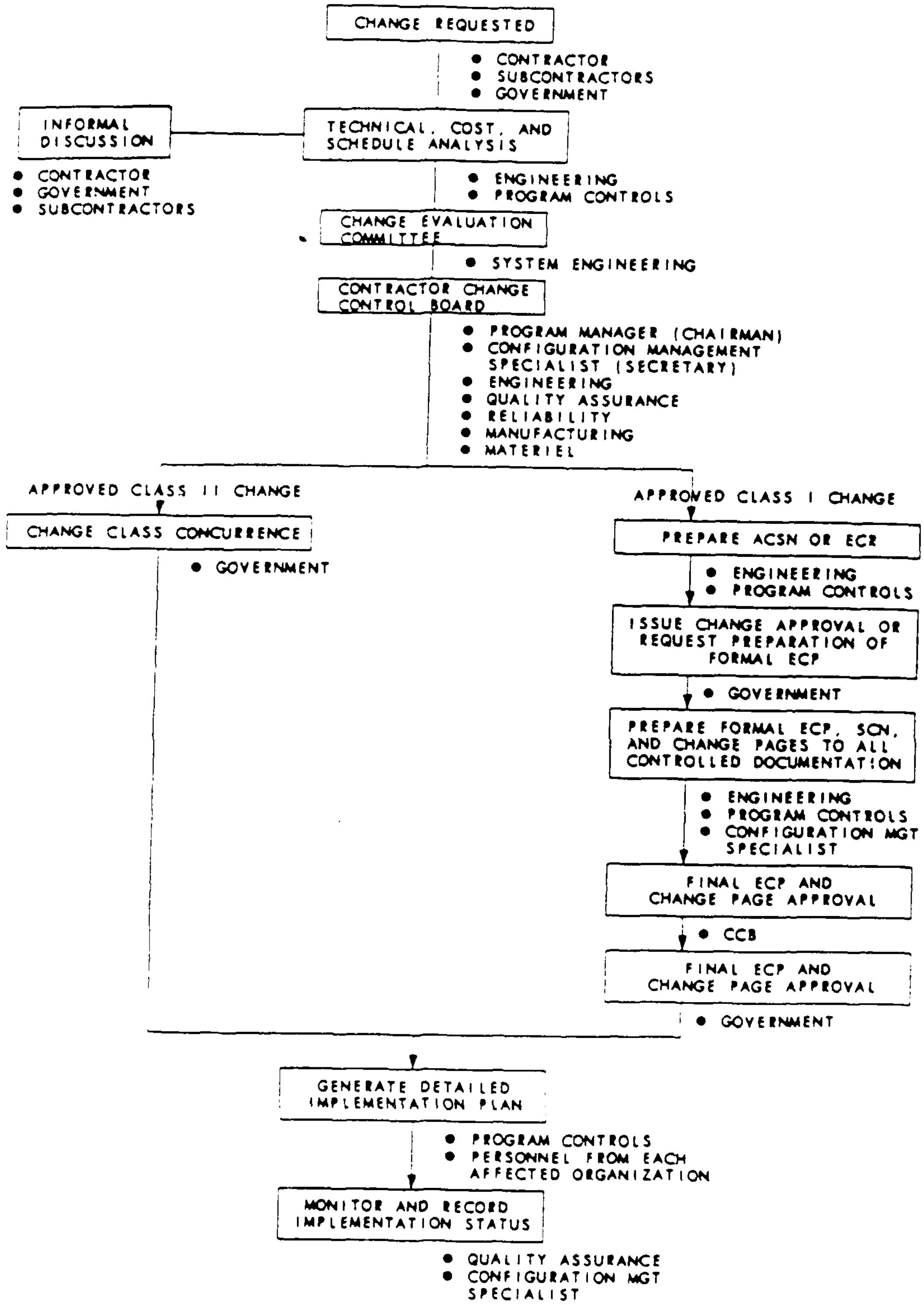

Figure 6. Process of Configuration Change Control (Ref. 12:p. 11-6)

process) to the government. It will be shown that with the proliferation of Class II changes and the deficiencies in documentation, the transfer of engineering cognizance is much more problematic.

The possibility of system performance degradation resulting from installation of incompatible components is an acute concern in the operating forces.(Ref. 13:p. 52) This observation was made in the summer of 1979 by the then Configuration Status Accounting (CSA) Planning Officer at Naval Air Systems Command, Washington, D.C. However, the same concerns are prevalent today with the operators and maintainers of FA 18 aircraft. The possibility of a technician ordering and receiving an improperly configured item is very real in the fleet and currently requires full time management at all levels of the support structure to solve these recurring problems. It will be shown that inadequacies within Navy Management Information Systems have generated a proliferation of independent data management systems. These systems are a statement from managers at various levels within, and in support of the FA 18 program, that a means to track the numerous component configurations inherent to an iterative, high technology program, does not exist.

III. CONTRACTOR CONFIGURATION MANAGEMENT INTERFACE

A. OVERVIEW

The purpose of this chapter is to develop an understanding of how private industry views Configuration Management, how they interface with Government policies and directives, and to take a brief look at methods utilized by contractors to achieve configuration control objectives.

The myriad of controlling documents required by DOD policy create a substantial burden on the corporate Configuration Management support system. Because configuration management is linked with company-wide activities (engineering, production, product support, etc.), an increased awareness of fundamental configuration management control systems will serve to enhance communications between configuration management and interfacing departments.

The present environment for technology development is fast paced and highly iterative in that changes and new developments appear with unprecedented frequency. An effective, efficient and accessible management information system is fundamental to the "management" of complex systems.

The contract, which is the primary controlling vehicle for configuration management, can have a significant impact on the entire acquisition program. In the government/

contractor interface activity, the accepted technical data baseline is identified, maintained, and controlled via the contract, which essentially covers the delivery of hardware (and software); the content and delivery of data; and/or the accomplishment of certain services. The principal contract elements, the Statement of Work (SOW), the Contract Data Requirements List (CDRL), the systems specifications, the general provisions, the identification of applicable documents and the application of the Federal Acquisition Regulations (FAR's - formerly the Defense Acquisition Regulations, and before that, the Armed Services Procurement Regulations or ASPR) clauses all may invoke requirements affecting the technical data baseline through acquisition management systems (both the hardware and the non-hardware types), data item descriptions (DID's) or other government generated constraints. (Ref. 14:p. 38)

B. RESPONSIBILITIES

It should be pointed out that while MIL-STD-480A addresses the task elements of configuration management (identification, control, status accounting and auditing), little emphasis is placed on management. In the eyes of many, and too often in practice, configuration "management" equates to merely performing the task elements. To put it another way, configuration managers are often nothing more

than "configuration recorders", required merely to track and record the accomplishment of various program activities without participating in the initial decisions about the task. It may be prudent to look at Configuration Management from another point of view; as involving three elements: administrative, clerical, and technical management, with an emphasis on technical management. (Ref. 15:p. 55)

Configuration management grew from and is still essentially a sub-discipline of engineering. It is generally accepted that configuration managers who are engineers tend to do the best job. This attitude stems from the interface required between the configuration manager and engineering throughout the development of the program. There seems to be less of a credibility gap when dealing engineer to engineer, and the depth of understanding of technical problems tends to be greater. (Ref. 15:p. 55) There is a tendency in many cases for the program manager to turn to engineering for all things technical, including technical management. The result in many cases is that engineering is expected to provide configuration (technical) management as well as the primary function of ensuring item performance. This dilution does not benefit either discipline. (Ref. 15:p. 56) Nevertheless, the engineer or engineering team having engineering cognizance over the functional and physical characteristics of the end item or CI, remains the most accurate and

reliable source of information relevant to the applicability of data, drawings or performance specifications of an item.

Within MCAIR, the Configuration Manager is a Subsystem Manager. As such he acts as a deputy program manager in matters relating to CM and is responsible to make known any problems which require program management decisions to appropriate higher levels of MCAIR FA-18 Program Management. Similar to other subsystem Managers, the Configuration Manager remains functionally in the Engineering Department. (Ref. 16:p. 6) The authority, prestige or influence of this manager, based on his positional relationships, could be counter productive to the fundamental configuration objectives. He is expected to "function" within engineering while maintaining loyalties to program management. This instilled conflict could, in essence, render the Configuration Manager ineffective.

Managing the copious amounts of data generated from the engineering function is another matter. A configuration definition is usually expressed by a set of operational drawings and specifications. These drawings and specifications define an operational item or system and are termed the technical data baseline for that item or system. Identification and verification of the data, documents, drawings and specifications that make up the technical data baseline is essential to baseline integrity. In the government's

contractor interface activity, the accepted technical data baseline is identified, maintained, and controlled via the contract. As stated in section A of this chapter, the principal contract elements may invoke requirements which could affect the technical data baseline. Confidence in the integrity of a technical data baseline is a crucial ingredient to credible Integrated Logistic Support (ILS) of the weapon system. Confidence in the technical data baseline can only be as strong as the confidence in the methods and procedures used to generate the information by which the baseline was established. Consequently, contract makeup can have a significant impact on the baseline. In today's technical environment, verification of the baseline can be complicated by the following factors:

1. Large volume of tasking documents that impact baselines;

2. Large volume of data-generating instructions, many of which are duplicative or inconsistent with each other and hence confusing to a contractor dealing with more than one government office;

3. Contract disparity;

4. Contract internal inconsistency;

5. Inordinate requirements imposed but semi-visible (FAR, multi-tier references); and the

6. Attempt to control data product separate from task. (Ref. 14:p. 40)

Figure 7, excerpted from the lists of Data Item Descriptions (DID's) tied to the source document MIL-STD 480 and

MIL-STD-480 Configuration Control-Engineering Changes

DID	INFORMATION
E-1102	Engineering Change Proposals
E-2037	Engineering Change Proposals
E-4527A	Engineering Change Proposal
E-5035B	Engineering Changes
E-6204	Exhibits, Engineering Change Proposals
E-21351	Summary, Engineering Change Proposal
E-23101A	Proposals, Engineering Change
E-23435	Proposals, Engineering Change
E-25603	Trainer-Engineering Change Proposal Summary
E-3128*	Engineering Change Proposals
E-2177	Software Change Proposal
E-2038**	Engineering Change Proposals
E-5034B	Engineering Changes (Short Form)
E-5383A**	Engineering Changes Commercial Format

*MIL-STD-490 Source Document
**MIL-STD-481A Source Document

MIL-STD-480 Configuration Control-Deviations and Waivers

DID	INFORMATION
E-2037	ECP's and Requests for Deviations and Waivers
E-3129	Request for Deviation/Waiver
E-5035B	Engineering Changes, Deviations and Waivers
E-20134	Change, Deviation and Waiver Form
E-23102A	Deviations, Request for
E-23103A	Waivers, Request for
E-5034B*	Engineering Changes, Deviations and Waivers
E-5035B*	Engineering Changes, Deviations and Waivers
E-20134**	Change, Deviation and Waiver Form
E-2038***	Engineering Changes, Deviations, Waivers
E-5383A***	Engineering Changes, Deviations, Waivers
E-2038***	ECP's and Requests for Deviations and Waivers

*MIL-STD-483 Source Document
**MIL-STD-490 Source Document
***MIL-STD-481A Source Document

Contract Package - Request For Proposol (RFP)

Acquisition Mgt. Systems (AMS's)		DID's	
Total AMS's Specified	152	Total DID's Specified	106
Hardware Impact Only	5	On DD1423	57
Cost Driver Areas	147	Not in DD1423	49
Identified in DODISS	79	Third Tier References	2,937
Not in DODISS	73		
Invoked via System Spec. (SOW)	85	Number of Data Requirements Not Identified in System Spec. (SOW)	49%
Invoked via Data Requirements	67		

	SOW Applicable Documents	System Spec. Applicable Documents
Total	88	34
Common	30	30
Missing	58	4

(Also includes conflicting requirements, e.g., drawing prep. MIL-D-1000A, DOD-D-1000B.)

(Ref. 12:p. 40-42)

Figure 7. List of DID's Exerpted from MIL-STD-480

representative [illegible] contract. [illegible] over abundance of direction [illegible] the same [illegible] available to be imposed [illegible] contractor. Much [illegible] direction may be essentially the same in intent but vary [illegible] in nature [illegible] all [illegible] these [illegible] may be invoked on a given contract. The [illegible] of establishing the integrity of the base [illegible] be seen. In addition, any variation in interpretation [illegible] government or contractor representatives from one constraint to a similar one could have a negative effect on the confidence level built [illegible] of the former constraint. In essence, while attempting to control the generation of data, [illegible] of what is being done toward controlling the [illegible] creative task effort. In other words, while one [illegible] is trying to manage and [illegible] data products, someone [illegible] managing [illegible] the [illegible] that generate [illegible] data. A Management [illegible] System (MIS) capable of integrating these functions [illegible] [illegible] configuration [illegible] through the using [illegible] customer's [illegible] environment should be [illegible] by [illegible] appropriate data base. [illegible] the [illegible] government data base [illegible] not integrated well, and consequently this is [illegible] than done.

C. FA 18 CONFIGURATION MANAGEMENT PLAN

Considerable variation exists within individual corporate structures for dealing with the preponderance of directives, regulations and specifications previously sighted. Typically, contracts for individual programs specify a requirement for the prime contractors to publish their configuration management goals, objectives, policies and procedures via a management plan. In the case of the FA 18 prime contractor, McDonnell Aircraft Company introduced the "FA-18 Program Configuration Management Plan" as follows:

> The F 18 Contract together with Addendum TS 169 to AR 59B and MR 18 "General Management Requirements for Project Management for F 18 Weapon System" establish the requirements for Configuration Management (CM). This plan defines the CM system which will be applied by MCAIR to the F 18 Program during FSD, Pilot Production and Production. This plan has been prepared to the format of Data Item Description (DID) DI-E 2035. (Ref. 16:p. 1)

The configuration management plan attempts to describe in relative detail MCAIR's internal guidelines to be utilized to satisfy specific contractual requirements for the management of the following CM elements and functions:

- Configuration Identification
- Configuration Control
- Change Classification, Preparation and Processing
- Requests for Deviations and Waivers
- Software Configuration Management

- Configuration Status Accounting
- Interface Management and Control
- Configuration Audits
- Subcontractor Control
- Interface with Northrop

Figures 8 and 9 illustrate and define the diversity of documents stipulated in the FA 18 Program Configuration Management Plan. It is important to realize, especially in the case of Class II Engineering Changes, that the internal procedures outlined in the plan are unique to MCAIR and would be different for other defense contractors. (Ref. 8) Of particular interest is the predominance of Class II documents and those documents used for minor deviations and waivers. Where approval authority is required for Class II engineering changes, and minor deviations and waivers, it is provided on site by the organization having plant cognizance. In this case a Navy Plant Representative Office (NAVPRO), but in other cases the authority could be an Air Force Plant Representative Office (AFPRO) or a Defense Contract Administration Services Plant Representative Office (DCASPRO). It is also important to note that only government concurrence in the classification decision (which would imply approval) is required for a Class II authorization. The complexity of the corporate organization, the internal policies, procedures and methods, the organizational

DOD-STD 480A
Configuration
Control

	ENGINEERING CHANGES		DEVIATIONS		WAIVERS	
	ClassI	ClassII	Critical/Major	Minor	Critical/Major	Minor
McAir Formats Used	DD1692	EO* DCN* EJS M&P(Rev) Std Parts* ECP/CCP Other Sub-contractor forms	Ltr Format DD1694	AMS* VAR* Temporary ECP/CCP DD1694 M&P(Dev)	Ltr Format DD1694	NR NRR MRR Clear Form C
Gov't Auth. Req'd	Procur'g Activ. Apprv'l	NAVPRO/05 Concurrance Required	Procuring Activity Required	NAVPRO/05-Approval	Procuring Activity Approval	NAVPRO/03-Audit NR/NRR Approval of MRR and Clear Form
When Auth. Req'd	Prior to Start of Effort	Prior to or Concurrent With Release to Manfact.	Prior to Start of Effort	Prior to Release to Manufact.	Prior to Start of Effort or Proceeding	Prior to Release to Manufacturing

(*) **Note:** Authorization of these documents is given concurrent with release to manufacturing.
(Ref. 8)

Figure 8. MCAIR Configuration Control Documents

EO - Engineering Order - The EO is a document which authorizes incorporation of a change in manufacturing before the drawing is revised. It is physically attached to in-house copies of the drawing. The drawing must be revised within one year. It is written against individual drawings.

DCN - Drawing Change Notice - The DCN is a DOD-STD 100B revision authorization document and is referenced in the revision block of the drawing. It describes the changes made to the drawing. It is written for each drawing revision and in-house is attached to the drawing until the next revision.

EJS - Engineering Job Sheet - The EJS is a document which is written for changes which affect more than one drawing or engineering group. It contains a brief description of the change and lists the drawing affected. It is similar to the DOD-STD 480A DD1692 form.

Vendor RCP/CCP - Requirements Change Proposal/Configuration Change Proposal - The RCP/CCP is used for subcontractor changes which are not dispositioned at the vendor location by the local government representative. It is similar to the DOD-STD 480A, DD Form 1692.

VAR - Variation - The VAR authorizes a temporary departure from an individual drawing and is physically attached to in-house copies of the drawing.

AMS - Authority for Material Substitution - The AMS provides the authority to substitute from raw material callouts on the drawing.

DD1694 - Request for Deviation - The standard DOD-STD 480A form. The contractor uses it for RFD's submitted by vendors/subcontractors.

STD Parts - Company Standard Parts - These are changes to company standard and are used on all company programs. Therefore, STD Parts Changes are counted separately. STD Parts are referenced directly on the drawing and are nonstandard parts (i.e. non-military).

M&P Specs - Material and Process Specifications - These are non-standard (i.e. non-military [illegible]). They are referenced on the drawing and are used on all [illegible] programs. They are counted and [illegible] separately.

NR - Nonconformance Reports - Used in the Waiver process.

NRR - Nonconformance Report, Repetitive

MRR - Material Review Record (Ref. [illegible])

Figure 9. MCAIR Class II Change and Minor Deviation [illegible]

culture, and the political power structure are [illegible] elements for Navy Configuration Managers to study and fully understand if they are to effectively interface with the corporate environment and provide accurate and cost effective Configuration Control.

B. CONTRACTOR MOTIVATIONS (VIEWPOINTS AND ATTITUDES)

Defense Contractors are in business to make a profit in order to perpetuate the well being of the company and there- fore the people who make up the company. An externality to the corporate environment is an atmosphere of perpetual political change inherent to the Government (in this case the customer) which dictates that short and long term cost-benefit decisions be made and reviewed continuously. Profit regulated business arrangements necessitate a constant search for cost saving methods and efficient manufacturing techniques while at the same time providing state of the art technology. This seemingly impossible juggling act is responsible for great strides in the development of tools and techniques utilized for efficient technical management. Efficiency and flexibility are the name of the game for keeping pace with changing Defense priorities.

Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) have come of age and automation has entered the change control arena. The capability exists [illegible]

effect functional and physical design changes so rapidly that change decisions must be made quickly. Otherwise, control of the product configuration can be lost, along with consequent cost control, inventory control and profit. Management information systems capable of integrating and tracking the high speed design process to facilitate CM exist within private industry. Unfortunately, MIS external to the corporate environment (within the government components and agencies) does not keep pace. Present day paperwork cycles are becoming ineffective and intolerable. (Ref. 17:p. 32) This can be especially true when integrating software and hardware requirements at the micro circuit level. It will be shown that a seemingly insignificant change in a circuit path of a micro chip or a subtle command change imbedded in a software test program can have detrimental short and long term effects for the user if the changes are undocumented or the information is buried within the contractor engineering department and not passed to the customer in the proper manner.

Corporate America has been forced to take the lead in automated data management and management information systems, due to an increasing demand for data by the customer. An extraordinary amount of data is generated as a result of contractual requirements. Unfortunately, while the government pays a substantial amount of money for this data,

much of the information is not utilized. In fact, a great deal of the technical data package is obsolete before it is even reviewed. Significant cost savings (time, money and manpower) could be realized by reviewing the contractual standards and Specifications for program relevance prior to placing the contractual burden on both the contractor and government program management.

A new frontier in configuration and data management is presenting itself. The challenge is to define it and apply innovation and imagination to the solution of its problems. To evolve with the times, it will be necessary to use the technology of tomorrow to manage the products of tomorrow. (Ref. 17:p. 37) The complexity of future CM will require an understanding and a dedicated commitment from professional configuration managers that present civil service and military training and rotation do not provide.

IV. FA-18 CONFIGURATION MANAGEMENT AND CONTROL ISSUES

A. OVERVIEW

The FA-18 Hornet represents a quantum jump in the application of advanced technology to the idea of a truly versatile, multirole, carrier-based tactical aircraft designed to perform both fighter and attack missions. The program has been a considerable source of controversy and even as recently as 1982 there was substantial pressure to terminate it in favor of other solutions to the operational requirement. It has been said that the program was not terminated more as a result of good fortune than good management because technical development problems, parochial interests, the decreasing priority of defense spending and adverse economic conditions combined to produce a particularly hostile environment for a new weapon system program. (Ref. 18:p. 1) In reality, good management may have been a key element in keeping the program alive.

The FA-18 was destined to be a configuration control challenge right from the start. Conceived as a light weight fighter out of the Navy's VFX (Experimental Carrier Fighter) program, a derivative of the aircraft would be designed to provide air to ground attack capability, changing the program designation to VFAX (Experimental Carrier Attack Fighter). It is not the intent of this thesis to document

the political issues affecting FA-18 procurement. Suffice it to say that Full Scale Development (FSD) contracts awarded in 1976 provided for 11 FSD aircraft to be followed by 400 F-18's and 400 slightly different A-18's. Continuing Congressional and DOD pressure for commonality changed this to 800 dual mission "strike-fighters" which differed according to mission by operational level configuration changes. (Ref. 18:p. 5) What emerged was a "software programmable aircraft", capable of providing the flexibility to readily adapt to new weapons, new technology, and new mission applications. Uncertainty generated by this flexibility would provoke lengthy discussions on how to tactically employ this type of adaptable technology. Indeed, as late as 1982, it was not certain what the actual designation of the aircraft would be.

The real beauty of this adaptable technology was the expediency with which the weapon system could be reconfigured to meet changing requirements dictated by expanded missions and altered threats. In regard to the latter elements, a Comptroller General report stated:

> As a rough generality, performance requirements for strategic programs undergo less frequent modification than do tactical programs. One of the principal reasons for the fluctuations in tactical weapon system programs seems to be the changes in mission concepts during the development phase and their relationship to other programs, either in inventory or under development. (Ref. 19:p. 13)

No aircraft weapon system is isolated from the impact of new weapons and capabilities which can be added to upgrade mission capabilities. The state of the art demonstrated in the FA-18 makes it highly susceptible to change. Consequently, change management has become an imperative requiring a more disciplined systematic approach. Present configuration management policies and procedures, while intricate in some respects, don't go far enough in others.

B. CLASS I ECP LOGISTICS PLANNING

Program Management is often referred to as the "management of change", which it certainly is in the broadest sense. However, all too often this broad interpretation of the management of change has not properly included change management. In this more limited context, change management is one of the major functions of configuration management and refers to the control of engineering changes or Engineering Change Proposals (ECP's). (Ref. 20:p. 1) In the case of Class I ECP's a more accurate terminology might be ECP management.

Within the FA-18 program, ECP management is coordinated by the program management office in accordance with current directives. The Assistant Program Manager for Logistics (APML), under the auspices of NAVAIR code AIR-04, assumes the responsibility for reviewing and assessing the short

and long term impact of the ECP on each ILS element. A go or no go recommendation is made based on this supportability evaluation. A supportability profile is thus established for the Configuration Item (CI). Since each FA-18 is considered a CI (apart from subsystem CI's within the aircraft), the supportability profile for the different airframe configurations, known as "lot numbers", becomes the basis for logistics support in the post production environment. Logistics support during the production phase of the acquisition process falls on support activities such as ASO and NESO, which assume engineering cognizance after IOC. Prior to IOC, the support activities perform logistics planning using a process entitled Logistics Support Analysis (LSA). LSA is defined as:

> . . .an iterative analytical process by which the logistic support necessary for a new system is identified and evaluated. LSA constitutes the application of selected quantitative methods to (1) aid in the initial determination and establishment of logistics criteria as an input to system design, (2) aid in the evaluation of various design alternatives, (3) aid in the identification and provisioning of logistic support elements, and (4) aid in the final assessment of the system support capability during consumer use. LSA is a design analysis tool employed throughout the early phases of system development and often includes the maintenance analysis, life-cycle cost analysis, and logistics modeling. (Ref. 21:p. 12)

An important output of LSA is the identification of and justification for logistic support resources: spare/repair part types and quantities, test and support equipment, personnel quantities and skill level requirements, and so on.

with this kind of information available in an "iterative process" from the beginning of development, it is significant to realize that the LSA is not considered a configuration management document. (Ref. 8, 9, 10)

Since the LSA is a working process for the support activities, and since support activities do not become involved in the ECP process until after the fact, logistics planning for any ECP is always a tail end process and always lead time away. Support activities such as NESO would rather the change process be proactive than reactive. If logistics planning could be started earlier in the ECP process, LSA parameters could be modified and evaluated, a more manageable transition of the supportability profile could be effected, and more cost effective support trade off options could be made available.

While those ECP's that were essential to FA-18 program success were properly recognized, justified and funded in accordance with the Configuration Management Plan and the spirit of MIL-STD-480A, a method of integrating the LSA process with the configuration control procedures would provide a significant enhancement to overall CM. Within the FA-18 program, a move is underway to do exactly that.

C. THE CLASS II EXPEDIENT

Class II engineering changes take place almost exclusively within the confines of MCAIR. In chapter III the

Class II approval process was delineated for the FA-18 program. Government concurrence for a Class II rating, or approval for a minor deviation or waiver is provided by the NAVPRO which properly resides on site within MCAIR facilities. The NAVPRO provides an impressive range of oversight activities. The NAVPRO St. Louis organization chart is presented in Figure 10. In order for the NAVPRO to deliver the type of oversight specified by its charter, it must actively and effectively interface with the corporate organization, structure and culture. Engineering cognizance covers a broad technical spectrum and requires a substantial engineering staff to keep pace with the number and type of Class II changes and minor deviations and waivers submitted. Toward this task, NAVPRO engineers have typically demonstrated a high degree of talent. However, time constraints and the very nature of their charter cause them to view a potential change more for functional issues rather than CM issues.

Class II specifications that prescribe the submission of a proposed change for concurrence in classification, leave the presentation format to the discretion of the manufacturer. The FA-18 Configuration Management Plan specifies the MCAIR change documents to be utilized for the Class II process (see Figures 8 and 9). Many such documents are reviewed by NAVPRO engineers daily and this activity is prioritized or concentrated in the most significant items.

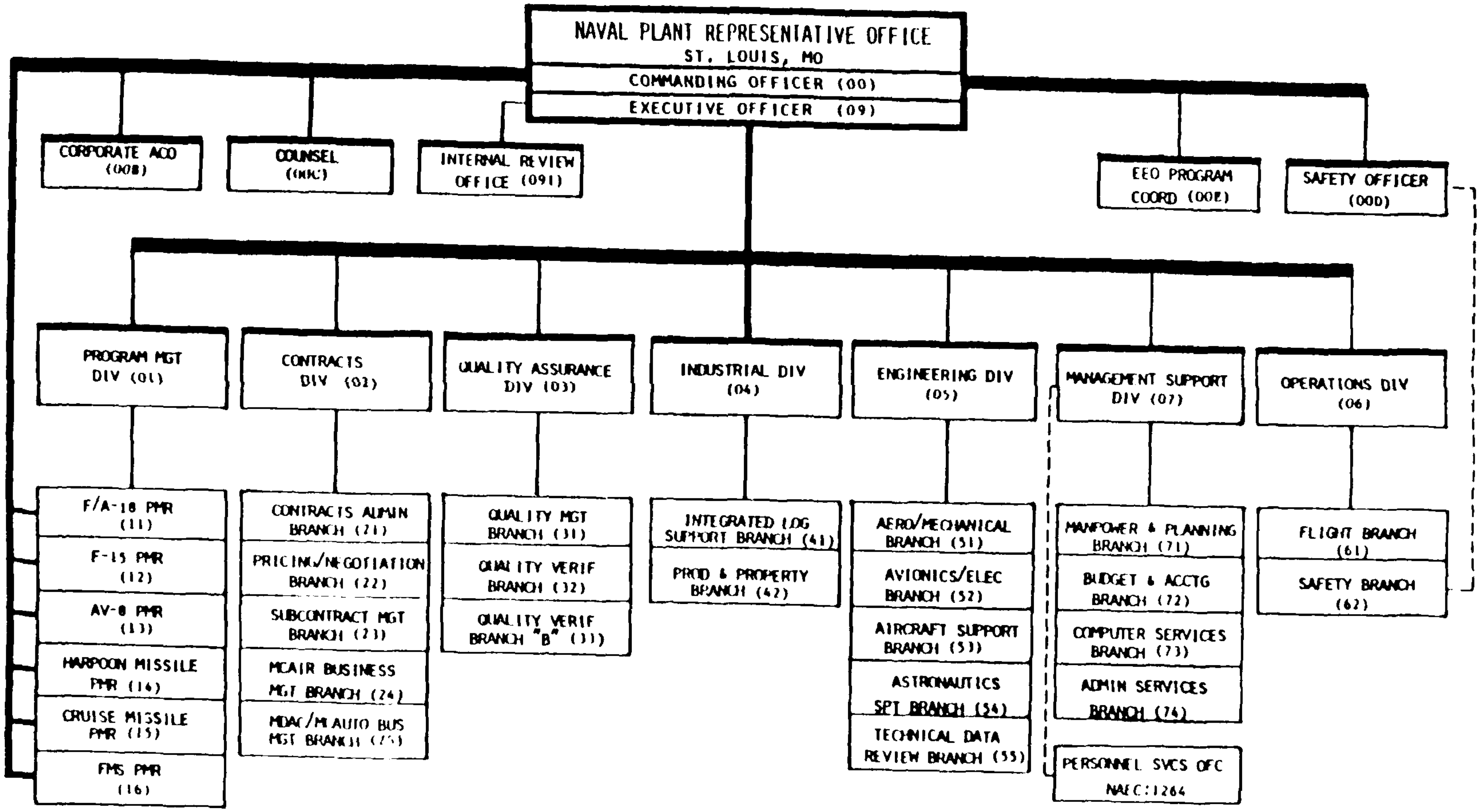

Figure 10. NAVPRO Organization
(Ref. 8)

When a document such as an Engineering Job Sheet [illegible] Engineering Order (E.O.) is submitted to the NAVPRO [illegible] engineering review, say for a change of a resistance value in an electrical system micro circuit, it will be reviewed [illegible] ality. If the change appears to be technically [illegible], the document will be signed off. The [illegible] views this signature as concurrence for a Class II [illegible]. Figure 11 illustrates this interface for [illegible].

A [illegible] example will sketch additional issues [illegible] to the Interchangeable and Replaceable (I&R) specification [illegible] in MIL STD 8500C. If the contract specifies that an item have total interchangeability, it means that the item, when taken from one aircraft, must fit and function in any other aircraft within the same supportability profile [illegible] numbers. Inability of the contractor to meet the specification requires an authorized deviation.

Many access doors and panels on the FA-18 are made [illegible] graphite epoxy composite material. The case in [illegible] at the door assembly drawing submitted for [illegible] approval on an E.O. The E.O. stipulated that the [illegible] be a trim to fit item and therefore Replaceable rather than interchangeable as called out in the spec. [illegible] NAVPRO engineer, it was functionally correct and technically acceptable. Therefore, the E.O. was signed off and the [illegible] assumed government concurrence in the Class II [illegible].

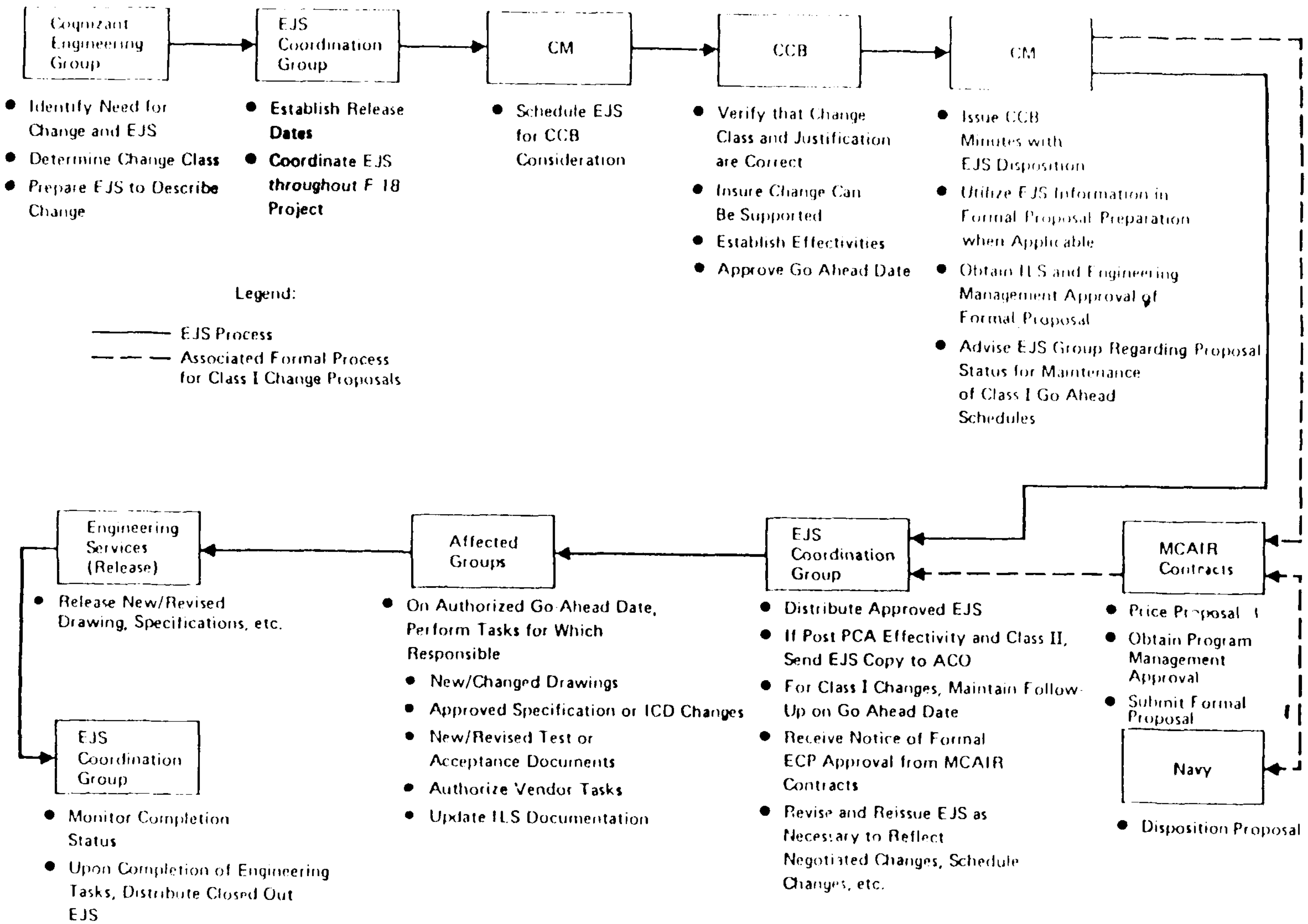

Figure 11. MCAIR Engineering Job Sheet (EJS) Process (Ref. 16)

Unfortunately, a Replaceable designation increases the spare parts profile in the field, which impacts life cycle cost. Additionally, because of the Class II authorization, support activities responsible for provisioning of spares have no visibility of the change, therefore demands for this item from operational units are unfilled and become a readiness degrader. (Ref. 22)

The extreme end of this process exists at the second and third tier vendor level. At this level, interface splits into two distinct categories: Government Furnished Equipment (GFE) and Contractor Furnished Equipment (CFE). For CFE/FA 18 interfaces, it is MCAIR policy that all subcontractor changes including Class II's and minor deviations and waivers be submitted to and reviewed by a MCAIR representative for evaluation and approval. (Ref. 16:p. 41) GFE/FA 18 interfaces are best described by the FA 18 Configuration Management Plan which states:

> MCAIR will participate with the Navy in the management of the interfaces between the F 18 aircraft and major GFE through requirements imposed by Associate Contractor Agreements (ACA's) and/or Interface Program Plans (IPP's), to the extent that such requirements are incorporated in the prime contract between the Government and MCAIR and the prime contracts between the Government and the Government Furnished Aircraft Equipment (GFAE) suppliers. (Ref. 16:p. 41)

Again, the primary focus is on the contract. Program interfaces and data transfer must be well defined contractually if CM is to effectively integrate GFE and CFE into the weapon system program.

In summary, there is a strong appeal [illegible] the [illegible] tion available through application of so-called [illegible] changes which are in reality Class I changes. The [illegible] benefits are real but they do not come free. In the current system, it is possible for a [illegible] change with a Class II authorization to generate a new failure mode. The new failure mode in turn may stimulate an increased discrepancy rate. The new discrepancy rate could affect the [illegible] profile and/or the maintenance philosophy. A new or additional piece of Support Equipment may be required along with a concurrent long term ILS impact. This domino effect carries with it substantial unprogrammed costs reflected in a variety of configurations, supportability problems, maintenance difficulties and degraded readiness.

SOFTWARE BREAKOUT

The concept of competition is the very foundation of our free market economic system. The underlying principle is simply that a competitive environment [illegible] individuals and organizations to excel. The Competition in Contracting Act of 1984 (PL98-369) as well as FAR [illegible] emphasize that full and open competition is considered standard. More specifically, DOD Directive 5000.1 states that:

> . . . effective design and price competition for defense systems shall be obtained to the maximum practicable extent to ensure that defense systems are cost effective and responsive to mission needs. (Ref. 4:p. 4)

A technique often utilized by program managers to reduce costs in the later phases of a program is to insert competition for ancillary logistic elements such as Support Equipment. This type of maneuver is known in acquisition parlance as "breakout" (i.e., breakout of specific items from the prime contractor). History records frequent use of the technique to breakout expensive logistic items from the prime contractor in an attempt to lower overall program costs. The A-7 program (one of the two aircraft that the FA-18 is designated to replace), provides a case in point.

Late in the A-7 program, avionics sophistication took a [illegible] jump from the A-7A and B models to the A-7D and E models. It was estimated that as much as seven million dollars might be saved by breaking out the GSE for a variety of equipment ranging from anti-skid brake test sets to the advanced test equipment required to provide complex avionics diagnostics and maintenance. While the intent was good, the result was an unfavorable logistics situation generating unprogrammed costs. The problems in the A-7 case were two fold. First, specifications and control documents were inadequate and incomplete. Second, the procuring agencies failed to apply MIL-STD-480 in the contracts. Consequently, and functional interfaces were not well defined, equipment specifications were not accurate and Support Equipment configurations were out of control. (Ref. 20: p. 27) As [illegible]

November 1975, millions of dollars and much time had been spent in an effort to regain control. The publication and data review alone involved nearly 4000 drawings. Significant costs were added to the program rather than the anticipated savings. A similar situation occurred in the FA-18 program when an attempt was made to break out very expensive, state of the art support equipment in the name of competition, to help reduce what was thought to be excessive developmental costs and overall program costs. The results of the Competitive Test Program Set (TPS) Acquisition Program was a series of developmental problems, delivery schedule slips, interface problems and cost over runs, all having a significant impact on program management. In fact, the FA-18 Program Manager (PM) lists the following FA-18 program impacts as attributable directly to the competitive TPS initiative:

- Decreased overall operational support flexibility
- Delayed implementation of Foreign Military Sales (FMS) commitment
- Increased interim support costs O&MN and APN
- Precluded identification and execution of a planned interim support program
- Exacerbated spares shortages
- Delayed organic Intermediate and Depot level maintenance
- Delayed support of Support Equipment
- Increased reliance on contractor maintenance service (Ref. [illegible]3)

The first competitive TPS contract awarded in 1983 took 18 months to execute. Costs for the competitive TPS endeavor up to 1985 were placed at 82.2 million dollars and 98 million dollars for interim support costs while the TPS's were being developed. (Ref.23) The FA-18 APML had this to say:

> Competitive procurement of TPS's has been neither timely nor cost effective. Although the decision to compete the FA-18 TPS's was made in mid CY-81, not a single production TPS had been delivered to the fleet by Harris GSSD or Sperry (Hercules) by November 1986. If competitive procurement is to be applied successfully in the procurement of TPS's, it must be competed through the prime contractor. This is the principle lesson learned by the FA 18 community. After completion of the development effort, NAVAIR can compete the recurring or do a first tier breakout of follow on procurements. All the tools of alternative acquisition must be in place before initiating a breakout action. (Ref.24:p.2)

Premature breakout is counter productive. Reasons for this are primarily management and availability of data, however, the PM states that an overly optimistic initial schedule failed to fully account for factors such as:

Clearly defined Automatic Test Equipment (ATE) software/hardware specification,

Availability of ATE,

Unstable design of several prime avionics,

Non-availability of complete technical data package (proprietary data/complexity),

Non-availability of integration assets (units under test- UUT's),

Interface problems between prime avionics and TPS developers,

Additional administrative (contract) delays associated with competitive program,

- Poor contractor performance (redesign of test strategies). (Ref. 23)

He further states that a realistic schedule would have allowed for:

- Recognition and planning for a realistic interim support period,
- Orderly implementation of interim support workarounds,
- More support trade-off options available at cost effective price. (Ref. 23)

The recommendations made by the FA-18 PM for the acquisition and support of support equipment are worth looking at because they not only reemphasize most of the issues previously discussed, but also signify an awareness that if passed on to future program managers should help preclude or at least limit a recurrence of the breakout problem:

- Review the acquisition and support implementation to ensure (1) a comprehensive systems approach, and (2) a corresponding management/organizational structure.
- Plan and execute the plan.
- Provide realistic delivery schedules (recognize, plan and execute interim support program.
- Ensure availability of GFE requirements to the developing agencies (data, UUT's, SE, etc).
- Ensure effective associate contractor agreements are implemented up front.
- Ensure future support equipment development contracts include incentive and penalty clauses to preclude/minimize major scheduling deviations or technical risk.
- Establish effective techniques to monitor contractor performance.

- Include provisions to efficiently accommodate changes into support equipments and UUT's as a result of ECP's.

- Support of ATE during integration phase must be fully funded up front to minimize ATE down time.

- Breakout cost savings must include cost of additional interim support during the interim support period. (Ref. 23)

The Navy Program Manager's Guide preaches prudence when introducing competition during or just prior to the production and deployment phase. Experience has repeatedly shown that the government's interests are best served when the PM takes the time and incurs the cost necessary to assure a demonstrated compatibility between any new source and the design disclosure before that source is allowed to manufacture articles for the service inventory. The PM should realize that when the design drawings, processes, procedures, and other documents necessary for the transfer of the production of a sophisticated piece of hardware are duplicated and transferred from one contractor to another, there is probably more knowledge and understanding of how to produce the article that is left behind in the minds and hands of the active producer than is obtained in the transferred material. Learning curves in production programs are not idle concepts. They are facts of production life and, as such, must be reckoned with. (Ref. 7:p. 4-35)

E. SAFETY AND READINESS

The FA-18 made its first flight in November, 1978. Since that time, the project has achieved fruition as FA-18's are deployed world wide. Maintenance technicians at the Organizational, Intermediate and Depot levels of maintenance perform preventive and corrective maintenance on the aircraft, its WRA's and related SRA's. By definition, Integrated Logistic Support (ILS) planning has its focus at this level. Indeed, ILS is defined as a management function that:

> . . .provides the initial planning, funding and controls which help to assure that the ultimate consumer (or user) will receive a system that will not only meet performance requirements, but one that can be expeditiously and economically supported throughout its programmed life cycle. A major objective is to assure the integration of the various elements of support (i.e., test and support equipment, spare/repair parts, etc.). (Ref. 21:p. 11-12)

Any break in the intricate management chain described previously has a major impact on the support of the aircraft and its systems. This is especially true when one considers the rapid turn around times required to operate from an aircraft carrier where missed sorties can have very grave consequences.

Configuration management and control manifests itself at the maintenance technician (user) level in the form of a part number (P/N) assigned to a specific repairable or nonrepairable item. A P/N is a number that enables one item

to be distinguished from another part numbered item. When the part number is preceded by the design activity code it is referred to as the "part identification" and is the primary reference to source drawings and specifications. It is important to note that while the part number has a direct relationship to a particular design activity, the design activity may not be the manufacturer of the configuration item. This presents an interesting tracking problem, especially in the case of Class II engineering changes. By definition, P/N's would not be altered for a Class II change because this would require a publication change. According to MIL-STD-480, any publication change forces an engineering change into the Class I ECP category (see Appendix B). The relevant question is; if a Class II change of any significance has been authorized (perhaps when it should have been a Class I ECP) how does the P/N, maintenance publications or any other logistic element get modified to reflect the altered parameters and show proper applicability? This question is of special concern to the maintenance technician who orders a part from a maintenance manual according to what is known as a "usable-on-code". The useable-on-code provides the technician visibility as to which P/N applies to the particular configuration of aircraft, WRA or SRA he is working on. The P/N information from a Class II change is passed to NAVAIR and ASO via a Design

Change Notice (DCN). The DCN is the MIL STD 100 authorization document for a P/N change. When ASO receives a DCN it will update the ASO data file. Unfortunately, the information stops at ASO and the DCN is not passed to the Naval Aviation Technical Services Facility (NATSF) to update the publications. The reason for this is that by definition, a Class II change should not require alterations to publications.

A typical scenario is one in which the technician orders an appropriate part specified in his maintenance manual (in this case a repairable). When the order is received by the supply organization servicing his area, and an issue cannot be made, the request is forwarded to ASO where it is cross referenced with the ASO data base. Occasionally, the ASO data base will alter the order with a modified P/N based on information they have received from NAVAIR via the DCN. The modification may be subtle such as a dash number change. In addition, it is not uncommon for the ASO item manager to be in direct contact with the prime contractor or have access to a contractor data base usually because there is six months to a year time delay for change documentation to get to ASO. The MCAIR data base utilized by the FA-18 Weapon System Manager at ASO is called the Technical Requirements Inventory Management (TRIM) System. TRIM allows the item

manager to plan ahead in procuring the latest item (it also implies that the Navy system is inadequate and cannot provide timely information). The item manager will then instigate an issue of the most up to date item with the latest applicable dash number. The technician now has a critical decision to make since he does not have visibility of the Class II documention that the ASO item manager has. The technician is governed by his publications and any deviations from his publications increases his liability. Consequently, he visualizes a safety of flight issue in the disparity of information he is receiving. The item he received may look like the one he needs, but he does not know what is inside. He does not know if the item he received from supply will function properly in the item he is working on. He will attempt to verify the correctness of the information by asking specific technical questions [illegible] ASO, usually of the item manager who is not technically qualified to answer these questions. The search [illegible] verification is on as the aircraft remains "not mission capable". The Type Commanders and the [illegible] Commanders get actively involved due to the [illegible] A great deal of time and energy are expended [illegible] verify the applicability [illegible] errant P/N. [illegible] finally culminates in [illegible] with the MCA [illegible]

who has cognizance [illegible] person who can speak knowledgeably [illegible] of what [illegible] actually taken place in the [illegible] interface with the rest of the system. [illegible] actually taken place [illegible] NAVAIR [illegible] representative.

[illegible]tunately, within the NAVAIR [illegible] one individual has assumed the responsibility [illegible] department within NAVAIR and [illegible]

[illegible] NAVA[illegible]

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The TDSA system, designed to provide the current configuration of all Naval aircraft and approved modifications to be installed, is replete with incomplete and unreliable data. As a result, the system output is not reliable without extensive reconciliation. (Ref. 36)

[illegible] 1982, the Naval Audit Service reported that the Naval Air Systems Command and the Naval Supply Systems Command:

[illegible] have not agreed on how to carry out and implement a configuration status accounting program and that management within the Department of the Navy has not resolved the problem. (Ref. [illegible])

[illegible], Naval Air Force, U.S. Atlantic Fleet studied [illegible] configuration related mishaps that occurred [illegible] month period ending 30 June 1978. The [illegible] that the Navy incurred over $100 million in [illegible] damage during that period as a result of [illegible] component removal, [illegible] removal, [illegible] replacement components [illegible] with fixed changes. (Ref. [illegible])

[illegible] Naval Aviation [illegible] Command Management [illegible] system (NA[illegible]M[illegible]) [illegible] is being designed [illegible] Naval aviation [illegible] with an automated [illegible] configuration status [illegible] system, but [illegible] able schedule [illegible] when NA[illegible]MI[illegible] w[illegible] implemented. (Ref. [illegible])

[illegible] of [illegible] have been [illegible] the Navy within [illegible]

FA-18 program, [illegible] systems have been created to help stabilize the [illegible] problem.

The primary source of FA-18 configuration information is the TRIM System [illegible] by MCAIR. It is updated rapidly, [illegible] Class II change data and can be [illegible] microcomputer. When [illegible] system was [illegible] and therefore not purchased by the Navy, it is interesting to note that [illegible] of the FA-18 program, is considered the source for [illegible] data and is even deployed [illegible] aircraft [illegible] wishing to access TRIM must now [illegible] with MCAIR. The systems [illegible] change compliance by aircraft [illegible] WSA [illegible] other [illegible] data.

[illegible] system [illegible] document [illegible] information [illegible] computer [illegible] data [illegible] system [illegible] systems is [illegible] users time. How[illegible] by present Navy [illegible] A [illegible]

[illegible] Configuration, update [illegible] report [illegible] developed. The key [illegible] initially to establish an ability [illegible] and to anticipate the [illegible] [illegible] input data, the system [illegible] the MCA [illegible] [illegible] This allows the [illegible] to update the [illegible] [illegible] while [illegible] [illegible] support. [illegible] [illegible] can be accessed by [illegible] number, [illegible] number. The system [illegible] [illegible] the [illegible] system [illegible] [illegible] data and provide the [illegible]

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V. CONCLUSION AND RECOMMENDATIONS

A. SUMMARY

DoD Configuration Management and Control goals and objectives listed in chapter one are sound. A determination of the costs and benefits of meeting these objectives was the aspiration of this thesis. Clearly, attempts to reduce [illegible] costs by constraining the tools, techniques and procedures customarily utilized to achieve the CM objectives, will derive only a limited short term benefit while incurring detrimental long range costs. Indeed, more [illegible] can be realized and significant [illegible] dynamic technical management [illegible] program [illegible] M [illegible] the program, [illegible] M [illegible] A [illegible] A [illegible] more [illegible] guration [illegible] ial [illegible]

breakdown in the Navy acquisition economy. The acquisition strategy plays a major role in how the CM objectives are achieved. While the strategy selected by the Program Manager (PM) will introduce many self imposed constraints, through such concepts as concurrency or the implementation of [illegible] competition through breakout, it is imperative that the PM consider the strategy impact on Configuration Management and Control. He must look beyond the complacent attitudes nurtured by the clerical and administrative aspects of CM incorporated through contractual stipulations, [illegible] on the technical management aspects necessary to identify and accommodate all of the Integrated Logistics [illegible] elements.

[illegible] A [illegible] program has fulfilled the [illegible] and [illegible] Configuration Management and Control [illegible] [illegible] to create [illegible] M [illegible] management [illegible] implementing contract [illegible] considerations.

CONCLUSION

[illegible]

effectively controlled the product baseline for all designated FA-18 configuration items. The following conclusions are stated in response to the primary and secondary research questions:

1. The complexity of configuration control problems have out stripped the present system's ability to handle them. The present system is inadequate and unable to capture the current fast paced, high technology environment. Indeed, changes that could have a substantial impact on system supportability can be made with alarming speed. The proliferation of locally developed systems designed to capture the dynamic environment of CM lack overall coordination, integration and standardization.

2. Given the state of the art in terms of Computer Assisted Design (CAD) and Computer Assisted Manufacturing (CAM), it is likely that private industry has a better grasp on technical management, especially in the utilization of management information systems for tracking a technical data baseline.

3. The Program Manager has ultimate responsibility and authority for configuration management. It is doubtful, however, that he has adequate tools and expertise at his disposal to perform the CM function. Fragmentation of the approval process, and delegation of authority, particularly in the area of Class II engineering change, sidesteps the LSA process and obscures supportability issues. In addition, the discipline of CM does not have a well defined career path. A high turn over rate of personnel within government technical management exacerbates this problem.

4. The system is too cumbersome to allow effective and efficient information flow. While the concept of "Acquisition Streamlining" aspires to cut back the amount of contractually required data, the requirement for transfer of a complete and accurate Technical Data Package (TDP) is valid and likely to intensify.

5. It is not likely that prime contractors or second and third tier vendors circumvent the system to avoid what they perceive as bureaucratic bottlenecks. It is likely, however, that they use the ambiguities in the system to avoid the additional expense of Class I ECP justification and processing when possible.

C. RECOMMENDATIONS

Based on the above conclusions, the following recommendations are made:

1. Undertake a program to identify and coordinate existing data bases relevant to CM. A means of integrating pertinent information and making it available for all DOD Configuration Managers should be developed.

2. Expedite the implementation of NALCOMIS if it is to be the ultimate Configuration Status Accounting tool. Implementation should include provisions for up line reporting to Functional Wings, Carrier Air Wings and Type Commanders.

3. In the absence of a coherent DOD CM system, Program Managers should undertake a long term cost/benefit analysis as to the purchase of a CM system from the prime contractor that would effectively and efficiently integrate the technical data baseline of their specific program with DOD CM systems.

4. Review MIL-STD-480 for ambiguities, variability and expediency in the classification of engineering changes. In the area of Class II changes, provide specific guidelines for the review and reporting of Class II changes. Reinforce the use of Class I ECP's. It may be possible to provide some middle ground for Plant Representatives to work in such as a dollar ceiling approval authority for certain Class I ECP's to encourage proper reporting of changes and to help expedite the process.

5. Provide training and establish a career path for professional Configuration Managers. An engineering background or demonstrated expertise in technical or engineering management should be preferred for CM candidates. Logistics training to [illegible]

familiarization of ILS and the LSA process should also be provided to government engineers tasked with the review of engineering changes.

D. RECOMMENDATIONS FOR FURTHER RESEARCH

Follow on research may be desired in the following areas:

1. A review of all ongoing Navy and/or DOD acquisition and procurement programs to identify and document the many different approaches to CM currently in use. Research in this area should include a detailed assessment of MIS.

2. Review in detail the NALCOMIS module designed to assume the configuration management, control, identification and accounting functions to determine if it will be capable of performing CM integration and analysis in order to provide the critical supportability information.

3. Review in detail all instructions, directives and regulations, in an effort to streamline the change approval process. Make recommendations to higher authority regarding reorganization of and improvements to the present system.

4. Perform a cost/benefit analysis to identify the tradeoffs of a government developed CM program as opposed to one developed by a prime contractor for a major weapon system acquisition.

APPENDIX A

REPRESENTATIVE CONTRACTUAL REFERENCES
[Ref. 5:p. B-1]

1. DOD Directive 5000.1, "Acquisition of Major Defense Systems"
This directive establishes policy for major defense system acquisition in the Military Departments and Defense Agencies. The management principles in this Directive are applicable to all programs (major and others).

2. DOD Manual 4120.3 M, "Standardization Policies, Procedures and Instructions"
The standardization provisions of this manual apply to DOD items and related engineering practices, processes, services and documentation which support the functions of design, development, procurement, production, inspection, supply, maintenance and repair. Chapter V, "Outline of Form and Instructions for the Preparation of Specifications and Associated Documents" is particularly applicable to configuration identification inasmuch as it addresses the preparation of Federal and Military specifications.

3. Federal Acquisition Regulations (FAR)
The single uniform acquisition regulation [illegible] Federal executive agencies. It applies to [illegible] acquisitions of property and services with [illegible] funds.

4. MIL-D-1000, "Drawings, Engineering and A[illegible]"
This specification prescribes the general [illegible] for preparing engineering drawings and [illegible]. It requires the acquisition of engineering [illegible] one or more specified intended use [illegible] prepared in one of three Forms. Both [illegible] must be specified.

5. MIL-S-83490, "Specification, Types and Forms"
This specification prescribes general [illegible] preparing specifications for DOD Components [illegible] types and forms of specifications and shows [illegible] usage in the various program phases.

6. MIL-STD XXX, "Configuration Management [illegible] Defense Materiel Items" (To Be Published)
This standard prescribes basic configuration [illegible] practices and is the basic document for [illegible]

implementing a configuration management program. It covers the general requirements for configuration management not covered in the other, more specific and detailed military standards. It also contains definitions of configuration management terms.

2. MIL-STD-100, "Engineering Drawing Practice,"
This standard prescribes procedures and format authorized for Form 1 and Form 2 drawings and associated lists prepared by or for DOD as prescribed by MIL-D-1000.

3. MIL-STD-130, "Identification Marking of U.S. Military Property"
This standard establishes the item marking requirements for identification purposes as required in stocking and replacing parts, sub assemblies, assemblies, units, sets and all other items of military property required by the DOD, with recognition of certain delimitations.

4. MIL-STD-480, "Configuration Control Engineering Changes, Deviations and Waivers"
[illegible] standard prescribes procedures and format [illegible] preparing an engineering change proposal [illegible] analysis of the implementation [illegible] with the [illegible] [illegible]

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12. MIL STD 490, "Specification Practices"
This standard sets forth practices for preparing, interpreting, changing and revising program peculiar specifications prepared by or for DOD components. It establishes uniform specifications practices comparable to the engineering drawing practices of MIL-STD 100.

13. DD Form 633-5, "Contract Pricing Proposal (Change Order)"
This form provides a standard format by which the contractor submits to Government a summary of incurred and estimated costs (and attached supporting information) suitable for detailed review and analysis.

14. DD Form 1423, "Contract Data Requirements List"
This form provides for the listing of data items required to be delivered under the contract.

15. DD Form 1634, "Research and Development Planning Summary"
This form provides for a uniform format for initiating and reporting information needed in reviewing and approving DOD research and development programs.

16. DD Form 1664, "Data Item Description"
This form describes a data item which the contractor is to deliver to the Government.

17. DD Form 1692, "Engineering Change Proposals"
This form provides a comprehensive, standard format for submitting proposed engineering changes.

18. Cataloging Handbook H4-1, "Federal Supply Code for Manufacturers"
The Federal Supply Code for Manufacturers (FSCM) is a coding system of numbers assigned to establishments which are manufacturers or have design control of items of supply procured by agencies of the Federal Government.

APPENDIX B

CHECKLIST FOR CLASSIFYING ENGINEERING CHANGES
(In Accordance with MIL STD 480A)
(Ref. 7:p. IV B 1)

This Checklist is to be used to classify engineering changes to any hardware specified for control in the contract in accordance with MIL STD 480A, paragraph 4.2.1.

The check sheet statements apply to the lowest level specified by base line identified in the PCI (Product Configuration Identification) as established in the contract.

Place a check ( ) in the appropriate YES or NO column for items 1 through 16. A check in the YES column indicates the change is Class I whereas no checks in the YES column indicates the change is Class II.

	YES	NO	Are any of the factors listed below affected:
1.	___	___	The functional or allocated configuration (contract SPECIFICATION for functional or allocated base line).
2.	___	___	The product configuration identification as contractually specified, (or as applied to government activities), excluding referenced drawings.
3.			The TECHNICAL REQUIREMENTS listed below contained in the product configuration identification, including referenced drawings, as contractually specified (or as applied to Government activities):
a)	___	___	Performance (outside stated tolerance).
b)	___	___	Reliability, maintainability or survivability (outside stated tolerance).
c)	___	___	Weight, balance, moment of inertia.
d)	___	___	Interface characteristics.

14. [illegible]

15. [illegible] configuration [illegible] subassemblies [illegible] CI's [illegible]

16. [illegible] drawings.

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